



Southwest Wind Power R&D Test Site Development at the National Wind Technology Center

Cooperative Research and Development Final Report

CRADA Number: CRD-12-00472

NREL Technical Contacts: David Jager and Arlinda Huskey

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Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-5000-77644
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Cooperative Research and Development Final Report

Report Date: August 17, 2019

In accordance with requirements set forth in the terms of the CRADA agreement, this document is the final CRADA report, including a list of subject inventions, to be forwarded to the DOE Office of Scientific and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: Xzeres Corp (no longer a viable business; formerly Southwest Wind Power)

CRADA Number: CRD-12-00472

CRADA Title: Southwest Wind Power R&D Test Site Development at the National Wind Technology Center

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Name and Email Address of POC at Company: David J Hoffrich | DHofflich@xzeres.com

Sponsoring DOE Program Office(s): U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Wind and Water Technologies Office

Joint Work Statement Funding Table showing DOE commitment: No NREL shared resources

Estimated Costs	NREL Shared Resources a/k/a Government In-Kind
Year 1	\$.00
TOTALS	\$.00

Executive Summary of CRADA Work:

Southwest Windpower, Inc. (SWWP) has been designing and distributing small wind turbines for more than 22 years and is the recognized global leader in the design, manufacturing and distribution of small wind systems (400-3000 watts). The company has been a pioneer in the development of wind technology and has built and shipped more than 170,000 wind turbines to over 120 countries worldwide. Headquartered in Flagstaff AZ, SWWP has sales representatives in over 88 countries. Applications for SWWP systems include residential homes, commercial properties, micro grids, remote cabins, telecom transmitters, offshore platforms, water pumping and sailboats. In addition, U.S. Department of Defense uses SWWP's products in Forward Operating Bases (FOB's), USGS uses them for remote monitoring of glacier movements and the CIA uses them to provide power seismic monitoring.

Today, SWWP plans development of new technologies to address distributed energy market needs and become even more aggressive in international markets. This strategy includes extensive Research, Development, Demonstration & Deployment (RDD&D) activities to improve existing production line into more simple, reliable, and cost-effective wind turbine systems. Important part of such activities is the field testing of the new systems, which should provide: (i) validation of the reliable operation of hardware and software; (ii) validation of numerical models of the system and its components; (iii) field comparison of various control and optimization strategies; (iv) customized reliability testing; (v) customized monitoring and analysis testing; and (vi) IEC certification testing (vii) field demonstration of system performance and reliability. Such field testing facility should encompass multiple towers and appropriate data acquisition systems.

SWWP is exploring to move part of the engineering department to Colorado, and execute its RDD&D strategies in this new location. Partnership with NREL will provide great insights into SWWP's RDD&D processes and more efficient commercialization by utilizing NWTC as the field testing site, and working close with NREL personnel. NWTC is ideally suited to strain the design. NREL is very experienced with customized and IEC testing.

During this project, Southwest Windpower aims to improve the value proposition of distributed renewable energy, and make it a competitive choice in the energy markets. As of today, more than 170,000 small wind turbines, manufactured in the U.S., are installed in more than 180 countries. With the improved value proposition, Southwest Windpower wants to create and address new market needs, substantially increase its sales domestically and internationally, which should have positive impact on the creation of American jobs, competitiveness of U.S. economy, export of U.S. products, and the use of renewable energy.

Summary of Research Results:

The purpose of this section is to capture the original or modified scope, completed work and outcomes of this project. DOE requires that this template address all the planned tasks in the Joint Work Statement.

Tasks Description

Project 1: Installation of four wind turbine towers and foundation and preparation of the test site.

Task 1.1: Site assessment, selection, and preparation; and foundation and tower installation

Task 1.1.1– Project management and test site preparation

NREL provided the following in support of CRADA # CRD-12-472:

1. Coordinated SWWP project construction activities with NREL requirements (e.g. safety, security, site access, environmental, electrical, telecommunication, documentation, schedule, and reporting).
2. Obtained NEPA approval.
3. Reviewed and approved the preliminary site layout.

4. Reviewed and approved the final detailed turbine foundation, civil, electrical, and telecommunication drawings, plans, schedule, and work.
5. Provided workspace, location for turbine including SCADA, and internet connection access.
6. Conducted electrical inspections.
7. Installed and connected meteorological instruments in accordance with the IEC 61400-12-1. (Figure 1)



Figure 1 Skystream Turbine with meteorological instruments (Site 1E2 South).

8. Conducted contractor safety review meetings and all other necessary requirements to allow SWWP and all SWWP subcontractors to perform work on site.

Southwest Wind Power in their initial scope of work documented, date March 15, 2012, stated four turbine towers would be installed at NWTC Sites 1E2 and 1E3. NREL completed safety documentation and approvals for four wind turbines and towers. Additionally, a meteorological tower was installed with instrumentation. Figure 2 indicates three of the four sites from a satellite image.



Figure 2 NREL Flatirons Campus, Site 1E

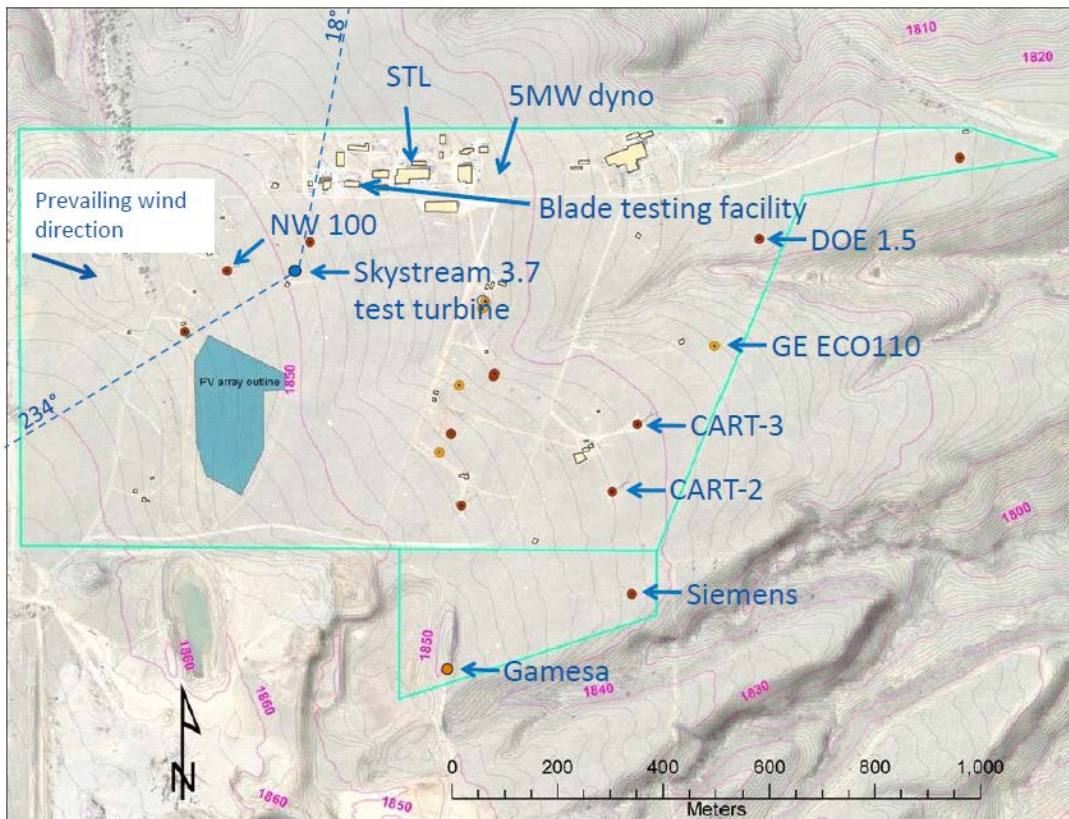


Figure 3 Map of test site including neighboring turbines and obstacles.

Task 1.1.2 – *Foundation and tower installation

NREL provided the following in support of CRADA # CRD-12-472:

1. Stored sensitive equipment indoors if enough room was available in existing facilities.
2. Supported unloading of components when on-site equipment was suitable to do so.
3. Conducted safety review meetings with SWWP and its subcontractors.
4. Approved the installation plan including lift plan.

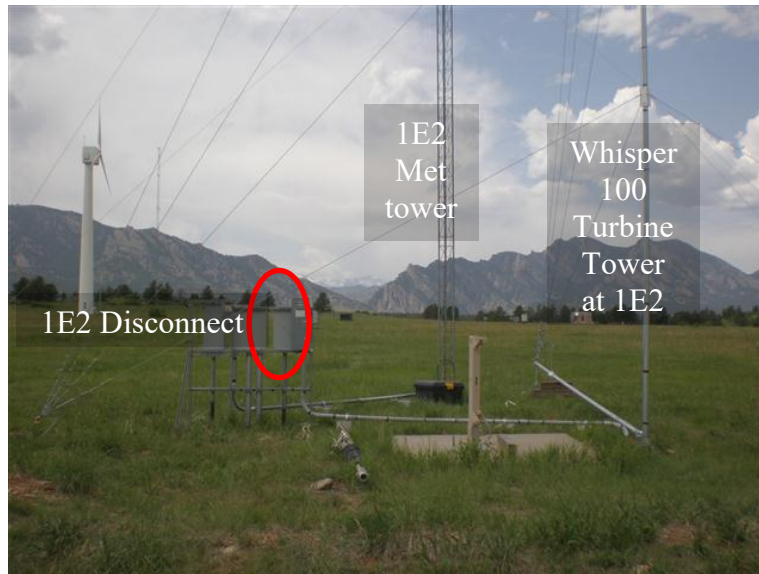
A SWWP Whisper 100 Turbine was installed at Site 1E.2 South and SWWP Skystream 3.7 turbines were installed at 1E.3 West and 1E.3 East (Figure 4). The fourth turbine tower for 1E.2 North was not installed for unknown issues.



Figure 4 View from 1E.2S looking south, Shed 1E and Site 1E.3E with Skystream turbine



Figure 5 Indicated Hazard Zone around the Whisper 100 wind turbine.



**Figure 6 1E2 Pad setup with met tower, disconnect and turbine tower
(Whisper 100, turbine not shown)**

Subsequent changes to the installed turbines included the removal of the Whisper 100 turbine from 1E.2S to facilitate the installation of the Skystream 3.7 that was originally installed at 1E.3W.

Project 2: Supporting SWWP RDD&D and accredited testing.

Task 2.1: IEC and RDD&D testing

NREL provided the following in support of CRADA # CRD-12-472:

1. Developed test plans.
2. Instrumented the turbine and meteorological tower. (Table 1)
3. Collect data.
4. Provide raw data to Xzeres as requested.
5. Provide test reports. (Figure 7 – Data Summary of Power Performance Test)

Items that NREL were not able to provide due to the turbine(s) and/or blades were not available for testing:

1. Perform a Blade Static test per IEC 61400-2.
2. Collect, analyze, and report preliminary sound data

Table 1 Equipment used in the power performance test

Instrument	Make, Model	Serial Number	Calibration Due Date
DC Current Transducer	OSI, CTH-101M-15	15123589	May 10, 2017
Primary anemometer	Thies, First Class	0609007	May 12, 2017
F/V for Primary	Acromag, TT339-0700	439939G	March 25, 2017
Reference anemometer	Thies, First Class	0707894	March 21, 2017
F/V for Reference	Acromag, TT339-0700	373785G	May 19, 2017
Wind vane	Met One, 020C with aluminum vane	G4706	May 12, 2017
Pressure sensor	Vaisala, PTB110	H4460092	April 08, 2017
Temperature sensor	Met One, T-200	0673552	April 08, 2017
Precipitation sensor	Campbell Scientific, 237	None	In situ
Data acquisition system	Compact DAQ w/LabView-based data acquisition, NI 9144 chassis NI 9229 NI 9217 NI 9205	197CC35 12B6DD2 13FAE1C 13E3D3F	April 20, 2018 April 19, 2018 April 21, 2018

A power performance test for the Skystream 3.7 at 1E.2S was performed in accordance to the International Electrotechnical Commission's (IEC) standard, *Wind Turbines – Power performance measurements of electricity producing wind turbines*, IEC 61400-12-1 First Edition [1], 2005-12, applying Annex H for small wind turbines as required. A confidential report was generated and provided to David J. Hofflich of Xzeres Corporation on 3 November 2016.

Power Performance Test Skystream 3.7

Sea-Level Density Power Curve

Turbine Specifications:

Serial Number: XW0023
 Rated Power: 2100 W
 Cut-in Wind Speed: 4.00 m/s
 Cut-out Wind Speed: - m/s
 Rated Wind Speed: 11 m/s
 Rotor Diameter: 3.72 m
 Control Type: Active
 Pitch Setting: Fixed

Site Conditions:

Location: NWTC, Boulder, CO
 Average Air Density: 0.95 kg/m³
 Measurement Sectors: 234-18 degrees true

Test Statistics:

Start Date: 7-Jun-2016
 End Date: 4-Oct-2016
 Amount of Data Collected: 1426.92 hours
 Highest Bin Filled: 15.00 m/s
 Test Completed?: Yes

Bin Wind Speed (m/s)	Bin Percent of Rated Power (%)	Number Data Points	Cp
0.55	-0.2	2,255	-3.86
1.02	-0.2	4,834	-0.82
1.52	-0.2	8,038	-0.19
2.01	-0.2	10,979	-0.09
2.50	-0.2	13,057	-0.04
2.99	0.1	12,583	0.01
3.48	0.8	9,564	0.06
3.96	2.4	6,415	0.12
4.45	5.1	4,567	0.18
4.94	8.6	3,339	0.22
5.43	12.8	2,525	0.24
5.92	17.7	1,819	0.26
6.40	22.6	1,134	0.26
6.89	28.9	651	0.26
7.38	36.7	493	0.27
7.87	44.4	400	0.27
8.36	53.4	365	0.27
8.85	60.2	452	0.26
9.34	67.8	396	0.25
9.83	74.3	315	0.23
10.32	79.2	232	0.22
10.81	79.6	158	0.19
11.30	77.5	108	0.16
11.79	73.1	92	0.13
12.28	70.6	58	0.11
12.77	64.3	35	0.09
13.26	69.4	19	0.09
13.75	66.1	29	0.08
14.24	67.7	11	0.07
14.73	69.0	10	0.06

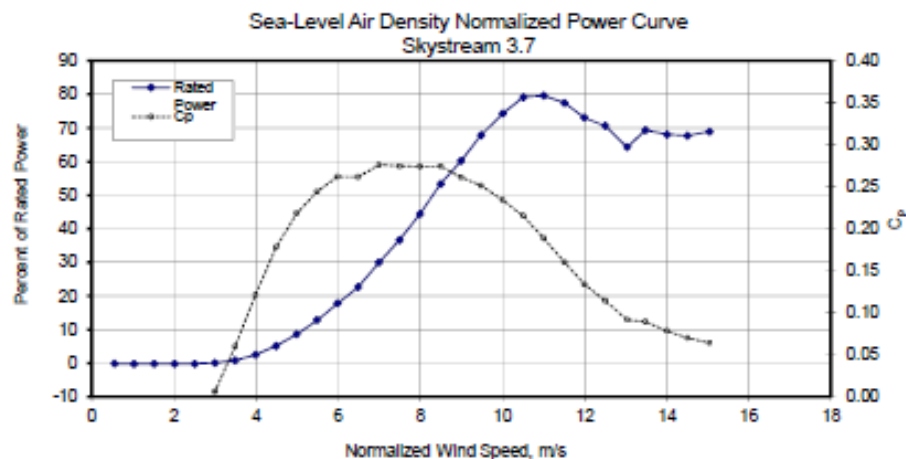


Figure 7 Power Performance Test, Skystream 3.7, Summary Page

Project 3: Turbine and Foundation Removal

Status: Not completed

The remaining Skystream 3.7 turbines and infrastructure have not been removed in anticipation of follow-on testing. Funds were kept to accomplish the removal at the end of testing.

There were multiple extensions on the CRADA to attempt to keep the scope of the project. During the course of the CRADA, the Skystream 3.7 and Whisper turbines changed ownership from SWWP to Xzeres. SWWP and Xzeres were small businesses with limited funding. Modification 5 to the CRADA extension was generated for Xzeres to receive anticipated funding for continued product development. Modification 6 to the CRADA was submitted and received approval from DOE but did not receive “Signature from the Partner”. This extension would have continued the CRADA for 16 additional months. The partner went out of business bringing the project to an end.

Subject Inventions Listing:

None

ROI #:

None